PB-229 692

WATER RESOURCES STUDY LINCOLN RESERVOIR EMBARRASS RIVER ILLINOIS. A PRELIMINARY STUDY OF POTENTIAL NEEDS AND VALUE OF WATER FOR MUNICIPAL, INDUSTRIAL AND WATER QUALITY CONTROL PURPOSES

Public Health Service
Evansville, Indiana

January 1964

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

ED 395
L5W2

PB 229 692

WATER RESOURCES STUDY
LINCOLN RESERVOIR
EMBARRASS RIVER
ILLINOIS

A Preliminary Study of Potential Needs and Value of Water for Municipal, Industrial, and Water Quality Control Purposes

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region III
Charlottesville, Virginia

JANUARY 1964

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

178
65

WATER RESOURCES STUDY
LINCOLN RESERVOIR, EMBARRASS RIVER
WABASH RIVER BASIN
ILLINOIS

A Preliminary Study of Potential Needs and Value of Water for Municipal, Industrial, and Water Quality Control Purposes

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region III
Ohio River Basin Project
Evansville Field Station, Indiana

In Cooperation With The

U. S. DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Louisville, Kentucky

January 1964

ii

Errata Sheet

Lincoln Reservoir Report
Embarrass River Basin, Illinois

The following revisions should be made in Exhibit F-6 of Volume III of Interim Report No. 2, Wabash River Basin Comprehensive Study:

On pages 23, 24, 25, and 26 in Table 7 under the heading "Treatment":

1. Delete fluoridation for the following municipalities: Broadlands, Charleston, Greenup, Hindsboro, Hume, Long View, Mattoon, Newman, Philo, Ste. Marie, Toledo, Tolono, Tuscola, Villa Grove, and Westfield.

2. Delete filtration for the following municipalities: Arcola, Ashmore, Casey, and Hindsboro.

3. Add iron removal for the following municipalities: Arcola and Casey.

4. Add softening for Lawrenceville.

On page 22 under "Existing Sources" delete Mattoon from the listing in sentence beginning, "The larger communities utilizing well fields for their municipal supply are:".

TABLE OF CONTENTS

Section		Page No.
I	INTRODUCTION	1
	Authority	1
	Purpose and Scope	1
	Acknowledgments	2
II	SUMMARY AND CONCLUSIONS	3
	Summary	3
	Conclusions	3
III	DESCRIPTION OF PROJECT	6
	Location	6
	Streamflow	6
	Water Quality	6
	Pertinent Data	8
IV	DESCRIPTION OF STUDY AREA	9
	Location and Boundaries	9
	Geography	9
	Climate	10
	Principal Communities and Industries . . .	11
V	ECONOMY	12
	Present Economy	12
	Area Included	12
	Agriculture	12
	Mineral Industries	13

TABLE OF CONTENTS (Cont'd)

Section		Page No.
	Manufacturing	14
	Transportation	17
	Income	17
	Population	18
	Projected Economy	18
	Employment Projections	19
	Population Projections	19
VI	WATER REQUIREMENTS	22
	Past and Present Water Use	22
	Municipal	22
	Industrial	22
	Existing Sources	22
	Ground Water	22
	Additional Water Needs	29
	Municipal	29
	Industrial	33
	Water Quality Objectives	34
VII	BENEFITS OF STORAGE	44
	Evaluation Method	44
	Alternate Plans	44
	Water Supply Benefits	45
	Adjusted Value of Storage	47

TABLE OF CONTENTS (Cont'd)

Section		Page No.
	Water Quality Control Benefits	47
VIII	BIBLIOGRAPHY	51

LIST OF TABLES

Table No.		Page No.
1	Water Quality Results, Embarrass River Basin	7
2	Summary of Mineral Production in Study Area	13
3	Number and Employment Size of Manufacturing Plants	15
4	Summary of Manufacturing Plants by Counties, 1958	16
5	Historical and Projected Employment, Study Area	20
6	Historical and Projected Population, Study Area	21
7	Municipal Water Systems, Embarrass River Basin	23
8	Quality of Municipal Water Supplies, Ground Water, Embarrass River Basin	28
9	Water Quality Results, Embarrass River Basin	30
10	Future Municipal Water Supply Requirements, Embarrass River Basin	32a
11	Industrial Water Requirements	34
12	Municipal Water Treatment, Embarrass River Basin	37
13	Water Quality Control Needs in MGD	39
14	Summary of Needs	40

LIST OF FIGURES

Figure No.		Page No.
I	Embarrass River Basin Map	52
II	Water Quality Monitoring Stations	6a
III	Population Projections	21a

I. INTRODUCTION

Authority

The District Engineer, Corps of Engineers, Louisville, Kentucky, by letter dated August 20, 1963, requested the U. S. Public Health Service to furnish ". . . information in accordance with the work plan now under negotiation for your studies for the Wabash River Basin Comprehensive Study . . . ." The letter transmitted Area-Capacity data for the proposed Lincoln Reservoir on Embarrass River as well as other pertinent data and further indicated that a higher seasonal pool could be attained if significant advantage could be gained.

Authority to conduct such studies is provided in the Federal Water Pollution Control Act (Public Law 84-660 as amended by Public Law 87-88 in 1961) and in the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, relative to the Water Supply Act of 1958 (Title III of Public Law 85-500 as amended by Public Law 87-88).

Purpose and Scope

This report provides a preliminary evaluation of municipal and industrial water supply and surface water quality control needs for the years 1976 and 2010 for the Embarrass River Basin, and the need for and value of water storage in the proposed Lincoln Reservoir for regulation of Embarrass River flow to meet these needs.

The Embarrass River Basin lies within the Counties of Champaign, Clark, Coles, Crawford, Cumberland, Douglas, Edgar, Effingham, Jasper, Lawrence

Richland, and Vermilion in the southeastern portion of the central part of Illinois.

Acknowledgments

Completion of this study could not have been achieved without the cooperation and assistance of Federal and State authorities and by local authorities within the basin. Information was furnished from their publications, records, and files.

Acknowledgment is made to the following agencies:

U. S. Geological Survey

U. S. Soil Conservation Service

Wabash Valley Interstate Commission

Illinois Department of Public Health

Illinois Department of Agriculture

Illinois Division of Waterways

Illinois State Water Survey

II. SUMMARY AND CONCLUSIONS

Summary

1. The proposed Lincoln Reservoir site is in the upper reaches of Embarrass River Basin and in the eastern-central portion of the State of Illinois. The proposed dam site is in Cumberland County, approximately nine miles south of the City of Charleston, Illinois.

2. The quantity and water quality of flows in the Embarrass River directly affect the communities and surrounding areas of Charleston, Newton and Lawrenceville, and may affect the City of Mattoon. The above communities are situated on or near the Embarrass River in the Counties of Coles, Cumberland, Jasper, and Lawrence (See Figure I).

3. Charleston and Mattoon are the greatest water consuming communities along the river and also discharge the greatest municipal waste loads into the river. Lawrenceville which is situated about eight miles from the mouth of the Embarrass River is a significant user of water supplied from a well field. The area surrounding Lawrenceville has a number of oil fields and an oil refinery. Information available at this time indicates that the oil industry discharges wastes into the river to the extent that the water quality in the river.

4. Estimates of storage for regulation of streamflow for the purpose of quality control are based upon the assumption that adequate treatment will be provided for all wastes.

Conclusions

1. It is expected that the urban population of the Embarrass River Basin areas including the Cities of Charleston, Lawrenceville, Mattoon, and

Newton will increase from about 48,000 in 1960 to about 96,000 by the year 2010. Of these population totals, the Cities of Charleston and Mattoon which combined had a population of about 31,000 in 1960 are expected to have a population of about 63,000 by the year 2010.

2. It is anticipated that the Communities of Charleston and Mattoon may need an additional water supply for industrial uses ranging from 0.7 to 1.5 mgd (million gallons per day) by the year 1976 and an additional supply ranging from 4.4 to 6.9 mgd for municipal and industrial purposes by the year 2010. This additional need can be supplied most economically from the proposed multi-purpose Lincoln Reservoir.

3. The Community of Newton will need a dependable river flow ranging from 1.2 to 1.5 mgd by the year 1976 and from 2.4 to 2.8 mgd by the year 2010.

4. The additional needs of small communities that are now using water supplies from wells downstream from the proposed Lincoln Reservoir site can be met by increasing the well field yield. The Lawrenceville area will need an additional 0.2 to 0.8 mgd in maximum dependable yield by the year 2010. This additional yield seems to be within the capacity of the ground water aquifer.

5. Water for quality control could be released from the proposed Lincoln Reservoir in an amount equivalent to an annual draft on storage which could be provided by an impounding reservoir of 5,400 acre-feet. This release could maintain a minimum flow of 21 cfs (cubic feet per second) which is believed reasonable because minimum releases will be held constant for a prolonged period of time. Consequently, the communities downstream will be deprived of the periodic small rises which would normally be available to the downstream users.

6. Approximately 20 acre-feet of annual draft on storage would be required to give a dependable river flow adequate for water supply needs at Newton of about 2.8 mgd. Newton's water supply needs could be taken from the release of 21 cfs leaving sufficient water downstream to assimilate Newton's adequately treated wastes.

7. A more detailed study is necessary to determine needs and assess benefits of storage for streamflow regulation for water quality control in the Lawrenceville area.

8. The proposed Lincoln Reservoir will afford benefits having a minimum value at least equal to the cost of building two single-purpose reservoirs for water supply for Charleston and Mattoon of 3,500 acre-feet and 1,700 acre-feet, respectively. It would also provide benefits for water quality control with a value equivalent to the cost of constructing a single-purpose reservoir having a capacity of 5,400 acre-feet upstream from Charleston. The value of these estimated benefits from water supply would be $1,300,000 for Charleston and $550,000 for Mattoon or about $79,000 and $10,000, respectively, per year. The value of benefit from water quality would be $1,600,000 or about $80,000 annually. The total benefit would be about $3,450,000 in terms of 1963 dollars or about $169,000 per year.

III. DESCRIPTION OF PROJECT

Location

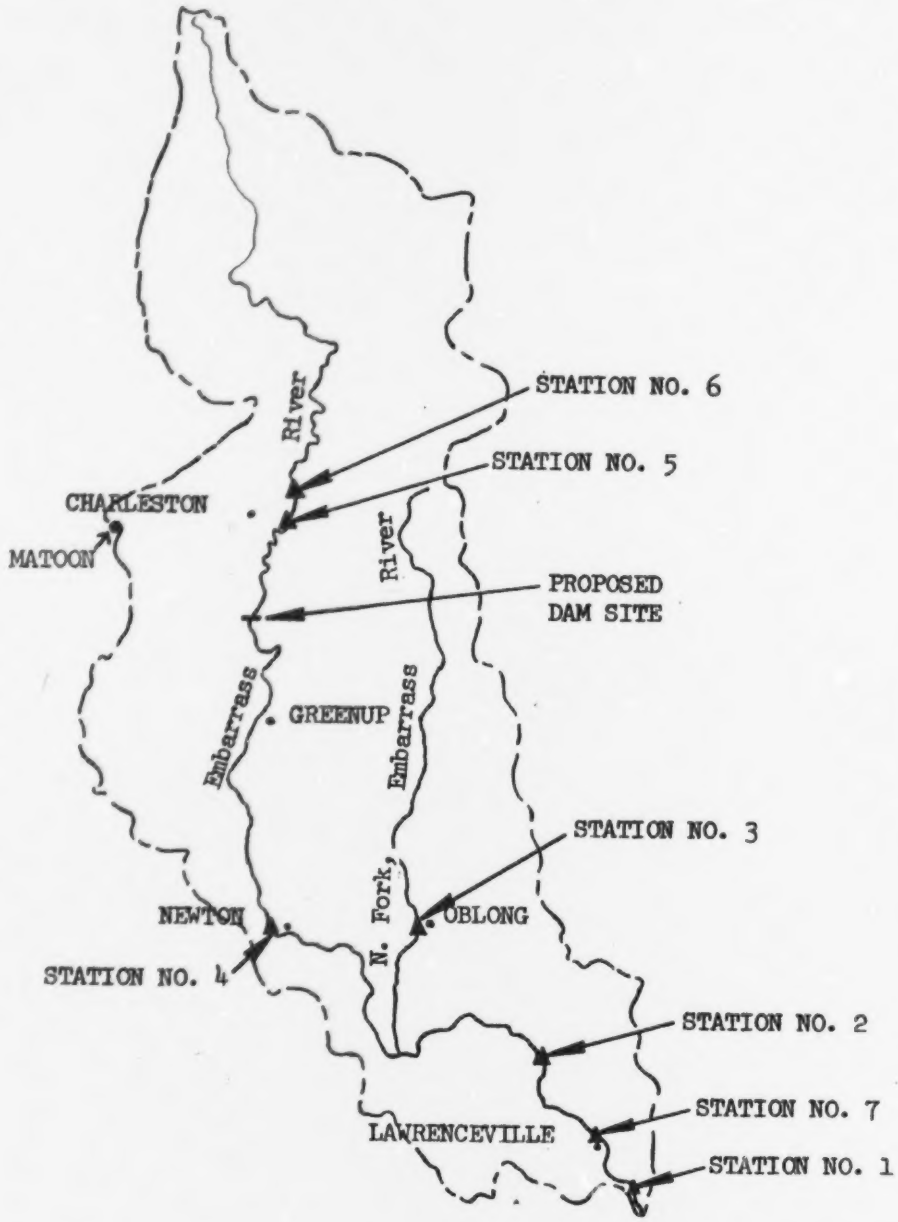
The reservoir site presently under study by the Corps of Engineers is in Cumberland, Coles and Douglas Counties, Illinois, in the upper reaches of the Embarrass River Basin. The proposed dam site is approximately 103 miles above the mouth of the river and about a third of a mile south of the Coles-Cumberland County Line (See Figure I).

Streamflow

The average discharge[1] of the Embarrass River at St. Marie based upon 51 years of record is 1,219 cubic feet per second (cfs) for a 1,513 square mile drainage area. Maximum and minimum mean monthly flows have been about 11,500 cfs and 4.4 cfs, respectively. The minimum daily discharge with a once-in-30-year occurrence is about 1.3 cfs and the minimum daily discharge experienced during 51 years of record was 1 cfs. The minimum 7-day average discharge with a once-in-5-year occurrence interval is about 21 cfs.

Water Quality

Water quality data have been collected by the Illinois Department of Public Health, Division of Sanitary Engineering, at various sampling sites along the Embarrass River (See Figure II). Table 1 gives the results obtained from samples taken at river monitoring stations at crossings of State Roads 16 and 130 over the Embarrass River. These results reflect the quality of water that may be expected to enter the Lincoln Reservoir upstream from Kickapoo Creek.



LINCOLN RESERVOIR REPORT

WATER QUALITY MONITORING STATIONS

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
OHIO RIVER BASIN PROJECT
EVANSVILLE, INDIANA FIELD STATION

FIGURE II

Table 1

Water Quality Results*

Embarrass River Basin

Date	Chloride	Sulfate	Alkalinity	Hardness	Spec. Cond.	Dissolved Sol.	Turbidity	BOD (5 day)	pH	Temp.	DO	Coli/100 ml	Enteroc./100 ml	Radio-activity Alpha	Radio-activity Beta	Bacteria/ml	Syndets
Station No. 5 - Hwy. #130 Over Embarrass River 2 mi. S. of Charleston.																	
9-24-58	26	-	288	332	640	380	10	0.7	7.9	--	6.75	2,700	160	--	--	--	--
11-17-59	16	-	136	222	440	270	110	2.8	7.5	34	10.8	60	800	--	--	40,000	0.0
1-17-61	29	66	292	324	660	400	12	1.5	8.2	38	15.0	110	100	Tri.	Tri.	2,300	0.0
9-6-61	11	30	134	220	420	250	35	5.9	8.4	78	9.2	120	2-			6,700	0.0
2-14-62	15	45	174	252	470	280	30	1.0	7.8	40	11.6	260	16	0.8	27	12,000	0.2
2-14-62	14	45	172	252	470	280	30	1.5	8.0	40	11.8	0	4	1.6	41	24,000	0.3
8-21-62	18	18	220	240	480	290	30	13.6	7.8	78	23.7	140	2-	0.4	26	7,000	0.01
5-28-63	8	110	180	228	440	260	80	8.8	8.3	70	9.5	570	24	1.1	9	5,000	0.1
8-27-63	48	130	104	270	570	340	40	1.6	7.6	74	7.2	640	16	1.1	13	2,800	0.0
Station No. 6 - Hwy. #16 Over Embarrass River 4 mi. E. of Charleston.																	
9-24-58	14	-	256	272	560	340	60	3.0	7.8	70	6.7	100	75	--	--	--	--
11-17-59	26	-	136	214	430	260	110	2.4	7.7	34	11.1	80	2400	--	--	44,000	0.0
1-17-61	73	65	296	340	590	350	17	1.5	7.7	38	10.8	30	8	3	Tri.	490	0.0
9-6-61	11	31	204	240	430	260	45	8.0	8.3	80	10.5	210	2			4,500	0.0

*From unpublished data furnished by Illinois Department of Public Health, Division of Sanitary Engineering.

The Cities of Mattoon and Charleston discharge treated wastes into Kickapoo Creek or its tributaries and these communities are expected to provide adequate treatment to their wastes. Even so, the recreational value of the portion of the reservoir extending up Kickapoo Creek may be decreased because of an aesthetic barrier involved.

Pertinent Data

For study purposes a minimum pool tentatively selected by the Corps of Engineers would provide 61,315 acre-feet and a seasonal pool would store a total of 126,765 acre-feet of water. These storage volumes would be achieved at elevations 584 feet and 596 feet for minimum and seasonal pools, respectively.

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

The Embarrass River Basin is located in the southeastern portion of the central part of Illinois and lies generally in a north and south direction with the lower portion of the basin lying in a northwesterly and southeasterly direction (See Figure I). The Embarrass River, which rises near the city limits of Urbana, drains an area of 2,438 square miles in parts of twelve counties: Champaign, Clark, Coles, Crawford, Cumberland, Douglas, Edgar, Effingham, Jasper, Lawrence, Richland, and Vermilion. The main stem of the Embarrass is approximately 130 miles long and discharges into the Wabash River about 6 miles downstream from Vincennes, Indiana. The basin is comparatively long and narrow. The two principal tributaries tend to broaden the basin somewhat but because they each follow a course generally parallel to the main stem the effect is minimized.

Muddy Creek with a drainage area of 213 square miles has its source about 8 miles southwest of Charleston and enters the Embarrass River about 6 miles southwest of Greenup.

North Fork Embarrass River drains an area of 361 square miles. It flows from a point near Kansas, Illinois, in a southerly direction and enters the Embarrass River about 10 miles south and somewhat west of Oblong.

Geography

Originating in the rolling ridges of southern Champaign County, the Embarrass River flows out onto the nearly level prairies of northern Douglas

County. Here the Embarrass River flows as a sluggish prairie stream meandering across the level uplands. In this area many channelized tributaries form the outlets for the numerous drainage districts which maintain surface ditches and tile lines to remove the excess water from several hundred thousand acres of highly productive farmland. Near the Coles-Douglas County Line the river drops abruptly into a gorge and follows this steep-walled, v-shaped valley southward to about Charleston, Illinois. For about 45 miles the Embarrass River flows at the bottom of a steep-walled gorge 50 to 70 feet below the adjacent upland. Near the Coles-Cumberland County Line, the river flowing in a preglacial channel, occupies a broad flat-bottomed valley with steep valley walls rising sharply to the upland. Throughout its course, the Embarrass River occupies a sharply defined valley.

Climate

Temperature in the basin, based upon 30 years of record during the period 1931 through 1960, ranges from a mean annual temperature of 52.7 degrees at Urbana, 53.6 degrees at Charleston, and 56.2 degrees at Vincennes, Indiana. For the same period of record, the mean monthly low was about 28 degrees for the month of January and the mean monthly high was about 78 degrees for the month of July.

Precipitation in the basin is as follows: mean annual precipitation for Urbana is 37 inches, for Charleston 38.6 inches, and for Vincennes 36.7 inches. The mean annual precipitation for the entire Embarrass Basin is approximately 38 inches.

Principal Communities and Industries

The principal communities located in the Embarrass River Basin are: Casey, Charleston, Lawrenceville, Mattoon, Newton, and Tuscola. The City of Mattoon is on the watershed boundary with sections of the community draining into the Little Wabash River; however, the city's treated sewage is discharged into Kickapoo Creek, a tributary to the Embarrass River.

Charleston and Mattoon have machinery manufacturing plants. An oil refinery is located at Lawrenceville, and Newton has a uniform manufacturing plant. Each community serves as a commercial center for the surrounding agricultural area but the basin has not experienced significant industrial growth.

V. ECONOMY

Present Economy

Area Included

The area of influence of the proposed Lincoln Reservoir Project covers 2,164 square miles and five counties in southeastern Illinois, i.e., Coles, Cumberland, Jasper, Crawford, and Lawrence.

Agriculture

Farming occupies a relatively prominent role in the economy of the study area. In manpower the agricultural industry engaged 6,334 workers and accounted for 16.1 percent of the labor force in 1960.

Even though the number of farms has declined since 1939, the harvested acreage has increased by 12 percent and the value of farm products sold has nearly doubled.

Agricultural Trends in the
Five-County Area
1939-1959

	Farms	Acres Harvested	Farm Products Sold*
1939	9,857	640,409	$ 26,339,943
1959	6,365	797,937	$ 50,345,923

* Expressed in constant 1959 dollars

Mineral Industries

The mineral wealth in the basin consists of petroleum, stone, sand, and gravel (See Table 2). Lawrence County produced 7,569,000 barrels of crude petroleum in 1960 representing 10 percent of the state total output. The annual value of mineral output approximates $29,000,000 for the study area. This amount represents about 5 percent of the total mineral activities for the state of Illinois. Employment data for the mineral activities hardly changed from 1950 to 1960. There were 1,222 employed representing 3 percent of the state total mineral industries employment in 1960.

Table 2

Summary of Mineral Production in Study Area *

Location	Minerals	Value
Coles County (1960)	Stone, sand, gravel	$ 790,000
Crawford (1960)	Sand, gravel	136,000
Cumberland (1959)	Sand, gravel	125,000
Lawrence (1960)	Sand, gravel	238,000
	Sub Total	$ 1,289,000
Coles County (1958)	Crude petroleum, natural gas	$ 1,424,000
Crawford (1958)	Crude petroleum, natural gas	9,251,000
Cumberland (1958)	Crude petroleum, natural gas	2,075,000
Lawrence (1958)	Crude petroleum, natural gas	15,036,000
	Sub Total	$27,786,000
	Grand Total	$29,075,000

* Sources: Minerals Year Book 1961, Volume III, Area Reports
Census of Mineral Industries 1958, Volume II, Area Statistics

Manufacturing

Manufacturing employed 7,336 workers, representing 18.6 percent of the labor force in 1960. In contrast, manufacturing employment in 1950 was 15 percent with 6,118 workers. Between 1954 and 1958 value added by manufacture * advanced nearly 50 percent, growing from $43,097,000 in 1954 to $63,937,000 by 1958. **

The manufacturing base of the study area is diversified in character. Table 3 lists manufacturing plants by major industrial category with ranges of employment. Of the 129 plants operating in 1958, 65 percent had fewer than 20 employees. Only .7 percent registered more than 250 employees. Ohio Oil Company in Robinson with 633 employees in 1960 had the largest employment force. In terms of plant establishments, the ranking industries are food processing and printing and publishing. However, in terms of overall measured employment according to 1960 data, the leading industry was the electrical machinery industry with 890 employees, followed closely by the non-electrical machinery industry totaling 778 employees, while food processing accounted for 616 workers.

Table 4 summarizes the manufacturing plant information in each county and indicates the possible high water intake plants and potential waste producers. All plants are included which had over 100 employees and whose 4-digit Standard Industrial Classification code industry is included in the

* Data on value added by manufacture for Lawrence County were not disclosed for either 1954 or 1958.

** Expressed in constant 1958 dollars

Table 3

Number and Employment Size of Manufacturing Plants
Study Area
1958

Type	EMPLOYEES (1-19)	(20-99)	(100-249)	(250-over)	Total
Food & Kindred Products	15	7		1	23
Tobacco Products					
Textile Mill Products					
Apparel & Related Products	5	1	3		9
Lumber & Wood Products	9	3	1		13
Furniture & Fixtures	1	1		1	3
Paper & Allied Products	5				5
Printing & Publishing	16	2			18
Chemical & Allied Products	3				3
Petroleum & Coal Products	3	1	1	1	6
Rubber & Plastic Products					
Leather & Leather Products	1	2	1	3	7
Stone, Clay, Glass Products	9			1	10
Primary Metals		2			2
Fabricated Metals	2	2			4
Non-Electric Machinery	5	4	1	1	11
Electric Machinery		1		1	2
Transportation Equipment	1				1
Instruments & Related Products	2				2
Miscellaneous	7	3			10
Total	84	29	7	9	129

Table 4

Summary of Manufacturing Plants by Counties, 1958*

SIC** Code	Industry Description	Number Plants	Employment Range	National Average Water Intake per Employee per Year Gallons
COLES COUNTY	58 Plants; 7 with over 100 Employees			
	High Water Intake Plants			
3569	Gen. Industry Machinery	1	100-249	145,000
3531	Construction Machinery	1	250-499	105,000
3641	Electric Lamps	1	250-499	106,000
	Potential Waste Producers			
2011	Meat Packing	2	1-19	
2011	Meat Packing	1	20-49	
2022	Natural Cheese	1	1-19	
CUMBERLAND COUNTY	12 Plants; 2 over 100 Employees			
	No High Water Intake Plants			
CRAWFORD COUNTY	26 Plants; 4 over 100 Employees			
	High Water Intake Plants			
2071	Confectionery Products	1	250-499	666,000
2911	Petroleum Refining	1	500-999	9,727,000
3261	Vitreous Plumb. Fixtures	1	250-499	229,000
3271, 2, 3	Ready Mix Concrete	3	1-19	1,386,000
	Potential Waste Producers			
2015	Poultry Dress. Plants	1	1-19	
2024	Ice Cream & Freez. Deserts	1	1-19	
JASPER COUNTY	14 Plants; 2 over 100 Employees			
	No High Water Intake Plants			
LAWRENCE COUNTY	19 Plants; 1 over 100 Employees			
	High Water Intake Plants			
2911	Petroleum Refining	1	500-999	9,727,000
2952	Asphalt Felt & Coatings	1	50-99	1,406,000
3271-2	Concrete Mix	2	1-19	1,386,000
	Potential Waste Producers			
2011	Meat Packing Plants	1	1-19	
2015	Poultry Dress. Plants	1	1-19	

* 1958 Census of Manufactures

** Standard Industrial Classification

listing of industries with an intake of over 20 million gallons per year in the Industrial Water Use Survey, 1958 Census of Manufactures. Plants with fewer than 100 employees are listed only if the industrial water intake per employee for their SIC categories is very high as shown in the Table.

Transportation

Since the Embarrass River is not commercially navigable at the present time, no river transportation is found in the basin. The area is serviced by only one airline, the Ozark, which provides short hauls to cities having multiple-line service. Four railways (New York Central, Nickel Plate Road, Illinois Central, and the Baltimore & Ohio) accommodate passenger travel and carry freight loads to all major commercial centers. Unhampered accessibility to all areas within the basin results from two highways (U.S. 45 and State Route 1) crossing the basin in the north-south direction and four highways (U.S. 40, U.S. 50, and State Route 16) running east-west. Interstate Highway 70 will cross the basin when completed. Intrastate as well as interstate trucking facilities insure the rapid transport of both import and export goods.

Income

The per capita cash income in the study area in 1959 was $1,595 as compared to the state per capita cash income of $2,181, and $1,849 for the Nation. Average median family income in the study area had risen from $2,594 in 1950 to $4,513 in 1960, an increase of 74 percent. During the same period the state median family income increased from $3,627 to $6,566, an increase of 81 percent. These figures indicate

that the study area is behind the state both in value of income and rate of increase. However, because of the rural nature of the study area and possibility of income in the form of farm products, the real income may compare somewhat more favorably with the state average than is indicated.

Population

The population in the five counties has remained stable during the thirty-year period 1930-1960. Population in 1960 numbered 103,433 which is nearly unchanged from the population mark of 103,513 recorded in 1930. The area's population comprised 1.02 percent of Illinois' population in 1960. Urban population stood at 45,212 in 1960 and composed 44 percent of all population, while rural-farm and rural non-farm population totaled 58,221 and represented 56 percent of the area's population. The five-county area is considerably less urbanized than either the state of Illinois or the Nation. Illinois was 80 percent urbanized and the United States was 70 percent urbanized in 1960.

There are only five cities in the area: Charleston, Mattoon, Robinson, Lawrenceville, and Newton. The largest is Mattoon whose population in 1960 was 19,088.

Projected Economy

Projections of the economy of the Lincoln Reservoir Project area of influence were derived from determining historical trend relationships between the study area and the state, and projecting those relationships using as the basis projections for the state prepared by the National Planning Association, Washington, D. C. Past trends were modified in accordance with judgment based on additional information. These projections may be modified, if necessary, upon receipt of the Arthur D.

Little Company, Inc. report of the Economic Base Study of the Ohio River Basin.

Employment Projections

Projected employment is given in Table 5. Agriculture and mining will continue to undergo downturns in employment as technical advances increase productivity. The non-commodity industries * are expected to continue to gain greater shares of the labor force. Manufacturing is projected to share a lesser percentage of the labor force in 1976-- 18.3 percent-- compared to its percentage share of 18.6 in 1960. The manufacture of electrical machinery will probably continue to lead in employment and non-electrical machine production will be next in importance.

Population Projections

Population, as related to expected patterns in state and national growth, is projected to vary from its stable path of the past and to reach 125,000 by 1976, and an estimated level of 180,000 in the year 2010 (See Table 6 and Figure III). Separate projections for townships and inclusive urban centers reveal an upward and moderate picture of population growth.

* Transportation-Communication-Utilities, Trade, Finance, Services, and Government

Table 5

Historical and Projected Employment
Study Area

	1950	% of CE[a]	1960	% of CE[a]	1976	% of CE[a]
Total Civilian Employment	40,809	100.0	39,328	100.0	48,680	100.0
Agriculture	9,356	22.9	6,334	16.1	4,020	8.3
Mining	1,244	3.1	1,222	3.1	850	1.7
Construction	2,619	6.4	2,316	5.9	3,700	7.6
Transportation-Com.-Utilities	3,928	9.6	3,215	8.2	3,800	7.8
Trade	7,457	18.3	7,964	20.3	10,300	21.2
Finance	827	2.0	1,045	2.7	1,500	3.1
Services	6,378	15.6	5,903	15.0	10,000	20.5
Government	2,882	7.1	4,003	10.1	5,600	11.5
Manufacturing	6,118	15.0	7,336	18.6	8,910	18.3
Furniture-Wood-Lumber	838	2.1	616	1.5	600	1.2
Primary Metals	101	.2	117	.3	120	.2
Fabricated Metals	303	.7	165	.4	220	.5
Non-Electric Machinery	254	.6	778	2.0	1,000	2.1
Electric Machinery	259	.6	890	2.2	1,800	3.7
Transportation Equipment	42	.1	30	.1	50	.1
Other Durables	727	1.8	651	1.6	750	1.5
Food	621	1.5	591	1.5	600	1.2
Textiles	71	.2	78	.2	10	-----
Apparels	377	.9	580	1.5	400	.8
Printing	287	.7	339	.9	460	.9
Chemicals	92	.2	459	1.2	600	1.2
Other Non-Durables	2,146	5.3	2,042	5.2	2,300	4.7

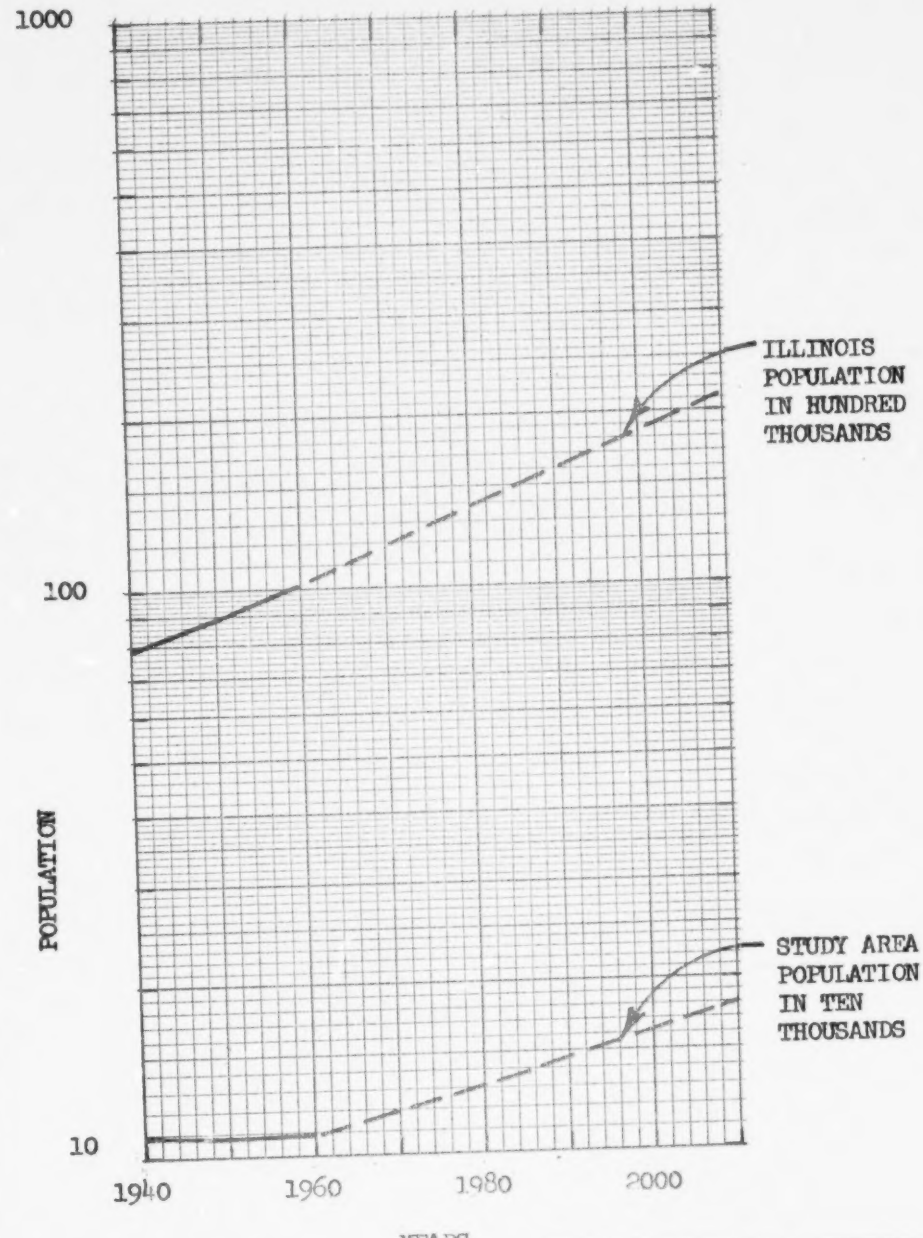
[a] Civilian Employment

Table 6

Historical and Projected Population
Study Area

	1950	1960	1976	2010
State of Illinois	8.7 Mil.	10.1 Mil.	13.0 Mil.	21.0 Mil.
Study Area (Coles, Crawford, Cumberland, Jasper, Lawrence Counties)	104,766	103,433	125,000	180,000
Coles County				
Charleston Township (Incl. Charleston)	10,713	11,924	20,000	28,000
Charleston Only	9,164	10,505	18,000	25,000
Mattoon Township (Incl. Mattoon)	17,906	19,138	26,000	35,000
Mattoon Only	17,547	19,088	24,000	31,000
Crawford County				
Robinson Township (Incl. Robinson)	8,130	9,056	12,500	20,000
Robinson Only	6,407	7,226	9,500	16,000
Jasper County				
Wade Township (Incl. Newton)	4,270	4,269	6,500	9,500
Newton Only	2,780	2,901	4,500	7,200
Lawrence County				
Lawrenceville Area* (Incl. Lawrenceville)	13,103	12,288	15,000	24,000
Lawrenceville Only	6,328	5,492	7,000	10,000

* This area includes Lawrenceville, Bridgeport, and Christy Townships.



LINCOLN RESERVOIR REPORT

POPULATION PROJECTIONS

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

OHIO RIVER BASIN PROJECT
EVANSVILLE, INDIANA FIELD STATION

FIGURE III

VI. WATER REQUIREMENTS

As the population increases and industrial growth occurs, greater demands will be made for water. Hence, the growth projected in the preceding section supports projections of seasonal water needs. Water uses by certain industries are shown in Table 2.

Past and Present Water Use

Municipal

Water use by the municipalities in the basin or within its influence is given in Table 7.[2]

Industrial

The major portion of industrial needs for water in the Embarrass River Basin are served from the municipal supplies.

Existing Sources

Ground Water

Wells are presently the chief source of water supply for most of the communities in the Embarrass River Basin. The larger communities utilizing well fields for their municipal water supply are: Arcola, Casey, Greenup, Lawrenceville, Martinsville, Mattoon, Toledo, Tolono, Tuscola, and Villa Grove. The Community of Sumner receives its water supply from Bridgeport which in turn purchases its supply from Lawrenceville.

Ground water in the basin is not exhausted even though it is utilized to a much broader extent than surface water. Most of the ground water is

Table 7

Municipal Water Systems

Embarrass River Basin

Municipality	Pop. 1960	1963 Est. Pop. Served	Source	Rated Plant Capacity (MGD)	Average Plant Output (MGD)	Treatment
Arcola	2,273	2,200	Wells	0.20	0.13	Filtration, Softening, Chlorination
Ashmore	447	447	Well	0.07	0.07	Filtration and Contact Beds
Bridgeport	2,260	2,230	(Obtains water supply from Lawrenceville.)		0.21	
Broadlands	344	322	Well	0.06	0.02	Iron Removal, Filtration, Fluoridation
Camargo	276	--	Well	--	0.005	None
Casey	2,893	2,975	Wells	0.44	0.20	Softening, Filtration, Chlorination
Charleston	10,505	11,500	Lake Charleston	2.00	1.0	Filtration, Taste and Odor Control, Fluoridation, and Chlorination
Flat Rock	497	515	Wells	0.24	0.01	None
Greenup	1,477	1,500	Wells	0.29	0.08	Fluoridation
Hindsboro	376	300	Wells	0.19	0.02	Filtration, Chlorination, Fluoridation
Hume	449	--	Well	0.12	0.01	Iron Removal, Filtration, Chlorination, Fluoridation

Table 7 (Cont'd)

Municipal Water Systems

Embarrass River Basin

Municipality	Pop. 1960	1963 Est. Pop. Served	Source	Rated Plant Capacity (MGD)	Average Plant Output (MGD)	Treatment
Kansas	815	810	Wells	0.12	0.04	Softening, Iron Removal, Filtration, Corrosion Correction
Lawrenceville	5,492	8,984	Wells	1.57	1.37	Chlorination, Filtration, Fluoridation
Long View	270	--	Well	0.07	0.01	Chlorination, Fluoridation
Martinsville	1,351	850	Wells	0.12	0.08	Iron Removal, Softening, Filtration, Chlorination
Mattoon	19,088	24,993	Little Wabash River Imp. & Wells	4.50	1.50	Softening, Iron Removal, Filtration, Fluroidation, Chlorination
Metcalf	278	200	Well	0.012	0.005	Chlorination, Corrosion Control
Newman	1,097	1,000	Drift Well	0.18	0.05	Softening, Iron Removal, Filtration, Chlorination, Fluoridation
Newton	2,901	4,400	Embarrass River	0.40	0.25	Filtration, Chlorination, Fluoridation
Oakland	939	980	Tributary of Embarrass River (Imp.)	0.24	0.06	Softening, Iron Removal, Filtration, Chlorination

Table 7 (Cont'd)

Municipal Water Systems

Embarrass River Basin

Municipality	Pop. 1960	1963 Est. Pop. Served	Source	Rated Plant Capacity (MGD)	Average Plant Output (MGD)	Treatment
Oblong	1,817	2,200	(Obtains water supply from Robinson)	0.22	0.14	
Pesotum	460	375	Well	0.12	0.02	Iron Removal, Chlorination, Filtration
Philo	740	800	Drift Wells	0.12	0.03	Iron Removal, Filtration, Fluoridation
St. Marie	347	350	Drift Well	0.015	0.012	Iron Removal, Filtration, Fluoridation
Stoy	185	--	(Obtains water supply from Robinson)			
Sumner	1,035	995	(Obtains water supply from Lawrenceville)		0.06	
Toledo	998	975	Drift Wells	0.18	0.05	Softening, Iron Removal, Filtration, Chlorination, Fluoridation
Tolono	1,539	1,570	Drift Wells	0.29	0.10	Softening, Iron Removal, Filtration, Fluoridation
Tuscola	3,875	4,000	Rock Wells	0.30	0.25	Softening, Iron Removal, Filtration, Chlorination, Fluoridation

Table 7 (Cont'd)

Municipal Water Systems

Embarrass River Basin

Municipality	Pop. 1960	1963 Est. Pop. Served	Source	Rated Plant Capacity (MGD)	Average Plant Output (MGD)	Treatment
Villa Grove	2,308	2,200	Rock Wells	0.40	0.13	Softening, Iron Removal, Filtration, Chlorination, Fluoridation
Westfield	636	615	Rock and Drift Wells	0.07	0.015	Iron Removal, Chlorination, Fluoridation

obtained from deposits of sand and gravel in the glacial drift, and a few of the public supplies are obtained from bedrock aquifers. Wells tapping the sand and gravel aquifers have yields ranging from 20 to more than 500 gpm (gallons per minute) while the sandstone aquifers yield less than 20 gpm and the limestone aquifers yield as much as 500 gpm.[3]

Prior to the glacial age, this part of the State had a heavily eroded landscape of deep valleys and high hills. During the glacier period many of these valleys were filled with glacial sand and gravel, and at these locations of unconsolidated material the possibility of obtaining significant supplies of ground water exist. Additional testing of sub-surface conditions must be made before knowledge of underground reserves of water is sufficient.[4]

Laboratory analyses have been performed on samples from pumping municipal wells of several communities throughout the basin. The results of these laboratory tests are listed in Table 8.

Surface Water

Mattoon has two impoundments on tributaries of the Little Wabash River. The first reservoir was constructed in 1937 with a surface area of 144 acres and the second in 1957 with a surface area of 1,270 acres. Combined they provide a safe yield of 9.0 mgd. These reservoirs are the chief source for Mattoon's water supply. Wells serve as a standby reserve.

Charleston's entire water needs are supplied from Lake Charleston, an impoundment of the Embarrass River. This reservoir was built in 1947 with a surface area of 337 acres and an original capacity of 693.6 million gallons. A survey made in 1960 by the staff of the Illinois Water Survey found that the reservoir had suffered a 40 percent loss in original volume due to siltation. The safe yield for Charleston has not been furnished.

Table 8

Quality of Municipal Water Supplies[3]

Ground Water

Embarrass River Basin

Municipality	Date	Iron (total)	Manganese	Calcium	Magnesium	Ammonium	Sodium	Silica	Fluoride	Boron	Chloride	Nitrate	Sulfate	Alkalinity (As Ca CO_3)	Hardness (As Ca CO_3)	Turbidity	Color	Odor *	Temp.
Arcola	6-48	6.0	0.3	67.6	29.3	15.1	112.5	26.3	0.2	-	51.0	0.2	0.6	504	290	50	25	0	55.5°F
"	12-55	4.1	-	-	-	-	-	-	0.2	-	21	4.8	-	356	232	24	0	0	55 °F
Casey	4-59	5.1	0.0	38.4	18.7	16.4	277	11.8	0.5	0.1	227	0.3	0.6	500	173	21	0	0	56 °F
"	4-59	2.3	0.1	65.2	29.7	5.3	83	15.6	0.5	0.1	48	0.1	1.4	412	285	12	0	0	55 °F
Greenup	6-48	0.3	0.2	75.1	29.6	Tr.	2.8	21.1	0.1	-	5.0	6.8	60.7	240	310	Tr.	0	0	54.2°F
"	4-59	0.4	0.1	68.1	28.8	Tr.	11	14.9	0.1	0.2	5.0	9.3	60.1	236	289	2	0	0	54 °F
Kansas	6-48	3.1	Tr.	93.1	34.9	8.1	21.4	28.0	0.1	-	6.0	Tr.	8.6	428	377	40	0	0	55 °F
Lawrenceville	4-48	0.3	Tr.	61.3	11.6	Tr.	0.9	16.1	0.1	-	7.0	11.6	26.5	156	201	0	0	0	56 °F
Martinsville	6-48	1.7	0.0	73.3	33.1	4.3	68.3	17.9	0.5	-	78.0	0.4	1.4	368	320	Tr.	0	Tr.	57.5°F
Mattoon	6-48	3.8	Tr.	93.6	37.0	5.9	2.3	21.8	0.2	-	4.0	1.6	58.2	340	386	40	0	0	55.6°F
Newman	6-53	1.1	0.1	69.4	26.2	1.3	33	22	0.5	-	5	0.0	1.8	348	281	1	0	0	54.4°F
Toledo	6-48	2.0	0.2	57.2	21.1	0.4	36.3	23.8	0.3	-	16.0	1.1	32.7	252	230	25	0	Tr.	52.5°F
"	4-59	1.3	0.1	52.5	21.8	Tr.	44	14.3	0.5	0.1	24	3.7	26.7	252	221	5	0	0	54 °F
Tolono	12-48	5.2	0.0	109.6	38.9	13.3	113.2	29.8	0.4	-	8.0	0.5	1.0	704	434	28	0	Tr.	54 °F
Villa Grove	6-48	0.1	0.0	51.7	24.5	0.5	115.9	14.7	0.2	-	79	0.1	11.5	360	230	0	0	H_2S	63.5°F
" "	6-60	0.1	0.0	51.4	25.9	0.5	118	10.4	0.4	0.1	83	0.9	11.9	364	235	0	0	0	64 °F

*Code

0 = None

Tr = Trace

H_2S = Hydrogen Sulphide

The only other community in the basin presently utilizing the Embarrass River as its source of water supply is Newton. For a period prior to December 1924, Lawrenceville obtained its water from the Embarrass. This source was abandoned because of the salt water from oil wells in the drainage area.[5]

Oakland has an impoundment on a tributary to the Embarrass River known locally as Lake Oakland. This reservoir has an impounded safe yield of 0.12 mgd.

Oblond and Robinson are presently purchasing their water supplies from the Community of Palestine, Illinois, located on the Wabash River.

Ranges in the quality of surface water in the Embarrass River are given in Table 9.[6]

Additional Water Needs

Municipal

Water demands for communities will vary with the economy of the area and with the availability of water of acceptable quality. Table 10 shows the estimated future per capita and municipal use for the major communities located in the basin. This tabulation gives the best estimate of future municipal water requirements that can be made at this time. If more detailed and more reliable data become available, a revision of estimates for future municipal use may become necessary. Light industrial uses are expected to be served from the municipal supply. Table 10 includes such anticipated use.

Table 9

Water Quality Results

Embarrass River Basin

(Downstream From Proposed Reservoir)

Date	Chloride	Sulfate	Alkalinity	Hardness	Spec. Cond.	Dissolved Sol.	Turbidity	BOD (5 day)	pH	Temp.	DO	Coli/100 ml	Enteroc./100 ml	Radio-activity Alpha	Radio-activity Beta	Bacteria/ml	Syndets
Station No. 1 - Two miles east of Billet on Rural Road																	
6-24-58	270	49.0	208	195	480	290	70	0.2	8.2	70	5.6	28,000	250	2.8	42.3	-	-
6-3-59	36	-	110	124	350	210	330	3.8	8.0	68	5.2	12,000	700	9	120	-	0.0
7-28-59	145	-	142	192	720	470	65	4.7	7.7	80	1.8	25,000	130	Tr.	34	120,000	-
11-17-59	92	-	76	120	530	320	440	6.9	7.3	36	8.8	9,000	14,000	29	Tr.	190,000	0.0
1-16-61	400	85	188	270	1780	1150	30	4.4	7.7	38	9.3	100	2	Tr.	0.0	5,400	0.0
9-5-61	96	27	260	265	710	430	50	7.7	6.2	80	7.8	570	10	2	0	440,000	0.0
2-14-62	40	39	142	208	480	290	80	1.7	7.6	40	11.1	130	-2/10 ml	2.5	105	330,000	0.2
8-21-62	39	23	212	220	540	320	55	4.0	7.7	80	5.0	88,000	800	2.0	26	100,000	0.0
5-28-63	50	38	192	244	670	400	90	8.2	8.4	70	9.0	23,000	50	1.9	11	100,000	0.2
8-27-63	42	293	136	330	820	490	180	8.6	8.1	74	5.8	16,000	110	2.3	71	21,000	0.3
Station No. 2 - Seven miles north and four miles west of Lawrenceville on Rural Road																	
7-28-59	39	-	188	204	510	310	100	1.1	8.2	78	6.5	10	14	4.0	Tr.	620	-
11-17-59	59	-	86	98	400	240	420	5.6	7.3	36	9.9	13,000	45,000	13	29	170,000	0.0
1-17-61	340	58	232	280	1580	1110	20	2.2	7.9	34	12.4	120	52	3	Tr.	940	0.5
9-6-61	92	25	252	264	610	370	60	3.7	8.1	78	7.8	400	18			6,200	0.0
2-14-62	33	40	154	224	480	290	70	1.6	7.6	40	11.8	260	6	5.4	59	5,800	0.2
8-21-62	22	14	208	234	489	290	60	3.2	7.8	80	6.3	410	26	2.1	37	6,200	0.0
5-28-63	57	38	176	216	770	460	170		8.2	70	8.2	14,000	130	3.6	16	4,000	0.0
8-27-63	12	115	92	156	380	230	200	1.9	8.1	74	6.7	1,200	26	2.9	57	19,000	0.0

Table 9 (Cont'd)

Water Quality Results

Embarrass River Basin

(Downstream From Proposed Reservoir)

Date	Chloride	Sulfate	Alkalinity	Hardness	Spec. Cond.	Dissolved Sol.	Turbidity	BOD (5 day)	pH	Temp.	DO	Coli/100 ml	Enteroc./100 ml	Radio-activity Alpha	Radio-activity Beta	Bacteria/ml	Syndets
Station No. 3 - Hwy. No. 33, 2 miles west of Oblong on North Fork Embarrass River																	
9-24-58	124	-	206	212	760	460	30	0.9	7.7	68	6.8	300	100	-	-	-	-
7-28-59	118	-	140	136	630	380	80	2.1	7.8	74	7.2	10	4	Tr.	38	670	-
11-17-59	270	-	88	152	1080	650	180	4.9	7.3	36	10.2	100	7,000	Tr.	55	53,000	0.0
1-17-61	285	40	128	144	1160	810	45	2.0	7.6	36	10.7	200	4,800	Tr.	Tr.	17,000	0.0
9-6-61	288	25	270	210	1160	700	25	4.4	7.8	76	6.3	36,000	36	-	-	2,600	0.0
2-14-62	111	55	138	230	710	430	30	1.7	7.6	40	11.0	100	12	3.3	94	6,300	0.4
8-21-62	188	10	220	580	970	580	70	3.0	7.6	78	5.4	230	58	1.0	42	40,000	0.0
5-28-63	102	28	204	240	1070	640	45	3.4	0.8	70	7.3	9,000	110	1.2	16	5,000	0.0
8-27-63	56	419	120	620	1220	730	60	6.2	7.7	74	7.7	750	20	0.8	28	8,000	0.3
Station No. 4 - Hwy. No. 130 at Newton																	
9-24-58	14	-	288	246	490	290	40	2.4	7.9	70	7.8	70	50	-	-	-	-
7-28-59	24	-	204	220	410	280	200	2.8	8.2	76	6.4	40	150	4.1	47	5,300	-
11-17-59	24	-	134	174	410	250	240	4.3	7.5	34	13.2	300	9,000	12	34	60,000	0.0
1-16-61	31	50	236	268	600	360	10	1.2	8.3	34	14.0	140	50	Tr.	Tr.	3,300	0.0
9-6-61	32	20	276	284	570	340	45	3.4	8.0	78	6.9	37,000	60	Tr.	Tr.	23,000	0.0
2-14-62	15	48	180	264	490	300	40	2.4	7.7	40	11.6	700	10	3.4	49	19,000	0.2
8-21-62	19	13	192	220	460	280	30	4.8	7.8	50	7.0	76,000	160	1.0	25	15,000	0.01
5-28-63	11	43	196	240	540	320	80	10.8	8.4	70	11.5	8,000	76	1.6	11	11,000	0.2
8-27-63	18	95	112	232	450	270	120	1.8	2.9	74	6.7	23,000	96	1.6	50	12,000	0.1

Table 9 (Cont'd)

Water Quality Results

Embarrass River Basin

(Downstream from Proposed Reservoir)

Date	Chloride	Sulfate	Alkalinity	Hardness	Spec. Cond.	Dissolved Sol.	Turbidity	BOD (5 day)	pH	Temp.	DO	Coli/100 ml	Enteroc./100 ml	Radio-activity Alpha	Radio-activity Beta	Bacterial/ml	Syndets
Station No. 7 - Hwy. No. 1, 1 mile south of Lawrenceville Refinery on Indian Creek																	
7-28-59	1600	314	164	212	5450	3270	80	4.2	7.9	76	3.5	4,000	84	Tr.	Tr.	28,000	-
11-17-59	450	186	170	232	1870	1120	20	4.0	7.6	36	10.2	40	70	Tr.	Tr.	4,300	0.0
1-16-61	520	106	84	220	2040	1430	45	3.5	7.6	36	9.7	46,000	600	11	Tr.	100,000	0.0
9-5-61	3500	139	280	310	11500	6800	30	6.7	8.3	78	9.2	340	40	-	-	74,000	1.
2-14-62	820	108	124	320	3040	1840	15	3.9	7.6	44	12.0	1,700	0	5.5	58	14,000	0.4
8-21-62	1550	56	172	360	5470	3280	50	3.5	7.6	77	5.4	2,200	130	2.	92	22,000	0.3
5-28-63	1250	110	232	480	5700	5420	100	5.3	8.4	70	9.6	19,000	190	5.	43	58,000	0.6
8-27-63	3000	1350	320	1860	18900	11340	25	21.	8.0	72	5.4	750	4	0.0	0.0	5,000	1.1

Table 10

Future Municipal Water Supply Requirements
Embarrass River Basin

Municipality	Population			Per Capita Use GPCD			Total Municipal Use MGD		
	1960	1976	2010	1960	1976	2010	1960	1976	2010
Mattoon T. (Incl. Mattoon)	19,138	26,000	35,000	--	125 to 150	175 to 200	-	3.2 to 3.9	6.1 to 7.0
Mattoon Only	19,038	24,000	31,000	79	125 to 150	175 to 200	1.50 -	3.0 to 3.6	5.4 to 6.2
Charleston T. (Incl. Charleston)	11,924	20,000	28,000	--	125 to 150	175 to 200	-	2.5 to 3.0	4.9 to 5.6
Charleston Only	10,505	18,000	25,000	93	125 to 150	175 to 200	1.00	2.2 to 2.7	4.4 to 5.0
Toledo	998	1,200	1,700	40	75	125	0.05	0.09	0.21
Greenup	1,477	1,500	1,800	41	75	125	0.08	0.11	0.22
Wade T. (Incl. City of Newton)	4,270	6,500	9,500		125 to 150	175 to 200	- -	0.8 to 1.0	1.6 to 1.9
Newton Only	2,901	4,500	7,200	86	125 to 150	175 to 200	0.25	0.5 to 0.7	1.3 to 1.4
St. Marie	347	380	450	52	75	125	0.02	0.03	0.06
Lawrenceville 5,492) Bridgeport 2,260) Sumner 1,035)		11,000*	16,000*	81	125 to 150	175 to 200	1.37 -	1.4 to 1.6	2.8 to 3.2

*Includes communities of Bridgeport and Sumner.

Future populations for the Communities of Toledo, Greenup, and St. Marie have been arbitrarily taken at a per annum rate of one half or one percent according to past growth. The population figures for these three communities are not based upon any economic factors and are not to be inferred as population projections or predictions. In the event the figures as used are erroneous, the error in anticipated needs will have only an insignificant effect upon the total needs for water from the Lincoln Reservoir.

Industrial

As indicated previously, industrial needs for water presently are satisfied from municipal supplies. It is not anticipated that the source of supply for the types of industries presently in the Embarrass River Basin will change. However, if any industries using large volumes are attracted to the basin, water use would increase at a rate greater than that computed for municipal needs. Therefore, the industrial needs for the larger communities are listed in Table 11. These communities represent locations where moderately large industrial water users would most likely locate in the Embarrass Basin. This tabulation of self-supplied industries, like that for municipal supply, is based upon the best estimates that can be made at this time. Revision of the figures in Table 11 may be required if further data become available.

Table 11

Industrial Water Requirements

Community	1960 MGD	1976 MGD	1980 MGD
Charleston	0	1.2 to 1.5	2.4 to 2.8
Lawrenceville	0	0.7 to 0.8	1.4 to 1.6
Mattoon	0	1.6 to 2.0	3.0 to 3.5
Newton	0	0.4 to 0.5	0.8 to 0.9
Total Industrial Needs	0	3.9 to 4.8	7.6 to 8.8

Water Quality Objectives

The water quality objectives used as a basis for determination of need for storage for regulation of streamflow for the purpose of water quality control are all related to the downstream land uses and in-stream uses of the waters. Where proper quality is not maintained, possible economic benefits may be foregone and the public health may be endangered. The objectives used in evaluating quality conditions in the Embarrass River Basin below the proposed Lincoln Reservoir have been based on present and prospective general recreational use of the Embarrass River, preservation of aquatic life, and its use as a source for raw water by the communities which might draw such supplies from the Embarrass River.

The bacterial coliform content is not used as an objective which could be achieved by additional storage. The cheapest solution to the bacterial content problem is considered to be chlorination of the effluent from waste treatment plants.

In setting water quality objectives for streams for the protection of aquatic life, mere survival is not enough. The minimum level selected

should be suitable for the continuous maintenance of satisfactory fish life and fish food organisms. Objectives are, therefore, based upon the environmental requirements of the fish species present in the river. On the basis of studies by the Public Health Service in the Cincinnati area, it was concluded that for a well-rounded, warm water fish population dissolved oxygen concentrations should not be below 5 mg/l for more than eight hours per day. Based on these considerations, a dissolved oxygen objective of 5 mg/l has been established for the Embarrass River below Lincoln Reservoir to preserve desirable aquatic life and to insure present and future recreational use of the river. The flows described as needed should achieve the dissolved oxygen objective in the river except that portion below Lawrenceville provided water of satisfactory quality is discharged from the Lincoln Reservoir. This could be achieved by multiple level outlets.

One of the declared public policies of the Sanitary Water Board Law is ". . . to provide that no waste be discharged into any waters of the State without first being given the degree of treatment necessary to prevent pollution of such waters . . ."[7]

It is further stated that ". . . Industrial wastes shall be treated or otherwise modified prior to discharge so as to maintain the following conditions in the receiving waters:

1. Freedom from anything that will settle to form putrescent or otherwise objectionable sludge deposits which interefere with reasonable water uses.

2. Freedom from floating debris, scum and other floating materials in amounts sufficient to be unsightly or deleterious.

3. Freedom from materials producing color or odor in such degree as to create a nuisance.

4. Freedom from substances in concentrations or combinations which are toxic or harmful to human, animal, or aquatic life.

These conditions to be maintained in the receiving waters following the discharge of industrial waste effluents are basic or minimum requirements . . ."

From an inspection of Table 12[8] it can be seen that all municipal wastes are or will be adequately treated. Adequate treatment at the present time amounts to 85 percent removal of the 5-day biochemical oxygen demand. Quantities of water required for water quality control have been computed on the premise that such treatment will be provided.

The most critical area of the Embarrass River, after construction of the proposed reservoir, will be at Newton. Located upstream from Newton and below the proposed reservoir are the small Communities of Greenup and Toledo. These communities can discharge adequately treated wastes into the Embarrass River which will carry releases from the proposed reservoir. The released flow will be adequate to assimilate such treated wastes and be of satisfactory quality for Newton's water supply if the releases are maintained at a rate equal to the minimum seven consecutive day average flow having a once in

Table 12

Municipal Waste Treatment
Embarrass River Basin

Municipality	1960 Population	Design Flow MGD	Average Flow MGD	Treatment	Discharge To
Bridgeport	2,260	0.02	0.25	Oxidation Ponds	Indian Creek
Casey	2,890	0.30	0.20	Sedimentation Trickling Filter	North Fork of Embarrass River
Charleston	10,505	1.00	1.45	Sedimentation Trickling Filter	Town Branch
Greenup	1,477	0.16	0.06	Imhoff Tank Trickling Filter	Embarrass River
Lawrenceville	5,492	1.00	0.55	Sedimentation Activated Sludge	Embarrass River
Lawrenceville airport*	5,000	0.50	0.35	Sedimentation Trickling Filter	Embarrass River
Martinsville	1,351	(New plant under construction)			
Mattoon	19,088	2.75	1.70	Sedimentation Activated Sludge	Kickapoo Creek
Newton	2,901	0.29	0.19	Imhoff Tank Trickling Filter	Embarrass River
Oblong	1,817	0.18	0.20	Sedimentation Activated Sludge	Big Dogwood Creek to Embarrass River
Sumner	1,035	0.06	0.20	Imhoff Tank Intermittent Sand Filter	Muddy Creek
Toledo	998	0.11	0.05	Oxidation Ponds	Cottonwood Creek to Embarrass River
Tuscola	3,875	0.61	0.25	Sedimentation Activated Sludge	Scattering Fork
Villa Grove	2,308	0.30	0.16	Sedimentation Activated Sludge	Embarrass River

*Potential only - Air Base presently closed.

five year frequency which is 21 cfs. This minimum release from the proposed Lincoln Reservoir will be ample to receive and assimilate Newton's adequately treated wastes.

It is believed this release rate is reasonable because minimum releases will be held constant for a prolonged period of time. Consequently, the communities downstream will be deprived of the periodic small rises which normally would be available to downstream users. Also, the release rate is not inconsistent with other uses. The Fish and Wildlife Service has indicated a need for 50 cfs for preservation of fish life in the stream.

The last downstream community on the Embarrass River is Lawrenceville which is situated approximately eight miles from the mouth of the river. As there is no other water use downstream from Lawrenceville, it appears that the releases from the proposed reservoir increased by natural inflow will be of sufficient quantity to receive and assimilate Lawrenceville municipal wastes.

An inspection of Table 9, page 30, discloses a chloride problem on Indian Creek near Highway No. 1 Bridge, one mile south of Lawrenceville refinery. Other problems at that point are also indicated by hardness, specific conductance, dissolved solids, and coliform. It is believed that, except for the coliform concentrations, most of the problem is due to land uses related to oil field operations and oil refinery operations. Oil field pollution will be studied and reported upon at a later date. Needs for water pollution control and the plants, efforts, and expenditures by private owners and local authorities to fill these needs will be described in detail.

Neither the adequacy of treatment or other methods of control of wastes at the source have been determined due to time limitations. Therefore, at this time needs for and value of storage for control of residual wastes from oil field operations could not be determined. It is possible that there may be a greater need for water downstream from the Lincoln Reservoir than has been shown in this preliminary evaluation.

The State of Illinois has prepared "Basic Industrial Waste Disposal Requirements" which are set forth in Technical Release 20-11 dated May 1, 1960.

Table 13 lists the minimum needs for water quality control in the Embarrass River Basin.

Table 14 gives a summary of the needs for water supply and for quality control in the Embarrass River Basin

Table 13

Water Quality Control Needs in MGD

Municipality	1960	1976	2010
Newton			
To receive municipal wastes	0.5	1.6 to 2.0	3.3 to 5.7
To receive industrial wastes	---	0.8 to 1.0	1.6 to 1.8
Total requirement for water quality control	0.5	2.4 to 3.0	4.9 to 7.5
Design flow	13.6	13.6	13.6

Table 14

Summary of Needs

Community	1960 MGD	1976 MGD	2010 MGD
Charleston (Charleston T)			
Municipal Water Supply	0.98	2.50 to 3.00	4.90 to 5.60
Design Flow and Storage	----	----	3. 3.
Additional Need	----	----	1.9 to 2.6
Industrial Water Supply	----	1.2 to 1.5	2.4 to 2.8
Total Additional Need	----	0.7 to 1.5	4.3 to 5.4
Mattoon (Mattoon T)			
Municipal Water Supply	1.50	3.25 to 3.90	6.13 to 7.00
Design Flow and Storage	----	----	----
Additional Need	----	----	----
Industrial Water Supply	----	1.6 to 2.0	3.0 to 3.5
Total Additional Need	----	----	0.1 to 1.5
Newton (Newton T)			
Municipal Water Supply	0.25	0.8 to 1.0	1.6 to 1.9
1-Day Flow (Once in 30-Year Frequency)	----	0.84	0.84
Additional Need	----	0.0 to 0.2	0.8 to 1.1
Industrial Water Supply	----	0.4 to 0.5	0.8 to 0.9
Total Additional Needs	----	0.4 to 0.7	1.6 to 2.0
Quality Control Needs			
Total Needed to Receive Municipal and Industrial Wastes	0.5	2.4 to 3.0	4.9 to 7.5
Design Flow	13.6	13.6	13.6
(7-Day Once in 5-Years)	----	----	----
Additional Need	----	----	----
Lawrenceville			
Municipal Water Supply	0.77	1.4 to 1.6	2.8 to 3.2
Maximum Dependable Draft	----	----	----
Additional Need	----	----	----
Industrial Water Supply	----	0.7 to 0.8	1.4 to 1.6

Table 14 (Cont'd)

Summary of Needs

Community	1960 MGD	1976 MGD	2010 MGD
Lawrenceville (Cont'd)			
Total Additional Water Supply Needs	----	----	0.2 to 0.8
Quality Control Needs			
Total Needed to Receive Municipal and Industrial Wastes	1.5	4.2 to 4.8	8.4 to 9.6
Design Flow	13.6+	13.6+	13.6+
(7-Day Once in 5-Years)	----	----	----
Additional Need	----	----	----
Total Additional Water Supply Needs Directly From the Proposed Reservoir and Returned to the Reservoir as Adequately Treated Waste	----	0.7 to 1.5	4.4 to 6.9

The flow of 21 cfs is believed to be a reasonable flow for the Embarrass River and would be sufficient to meet the needs along the river as explained previously. To maintain a flow of 21 cfs (13.6 mgd) in the Embarrass River would require a draft on storage which could be provided by an impounding reservoir with 5,400 acre-feet of storage capacity. This draft on storage would be for water quality control purposes.

Plan for Supplying Future Requirements

The City of Mattoon has an impoundment that provides a safe yield of 9.0 mgd and is not expected to need more water in the near future but estimates of municipal and industrial needs indicate that as much as 1.5 mgd additional

water may be needed by the year 2010. This additional water can be obtained from the proposed Lincoln Reservoir by providing a useable storage volume of about 1,700 acre-feet. An alternate to the use of water from the proposed Lincoln Reservoir would be to construct a single-purpose reservoir on one of the small tributaries to the Embarrass or the Little Wabash Rivers.

The City of Charleston is expected to be in need of additional water by the year 1976 because of siltation of its reservoir on Embarrass River and the accompanying loss of storage volume. It is anticipated that Charleston will need additional water in the range of 0.7 to 1.5 mgd by 1976 and from 4.3 to 5.4 mgd by the year 2010. Useable storage volume of about 3,500 acre-feet in excess of the river flow and present storage would provide the quantity of water needed to give a firm yield of 5.4 mgd. Loss of existing reservoir volume by unexpectedly rapid siltation could create a need for additional water for Charleston much earlier than 1976.

An alternate to the use of water from the proposed Lincoln Reservoir would be the construction of a single-purpose water supply reservoir on one of the small tributaries of Kickapoo Creek or the Embarrass River.

Toledo, Greenup, and St. Marie use wells for water supply. It is anticipated, on the basis of presently available information, that these communities can obtain sufficient supply from ground water sources and should do so even though all are within a distance of the Embarrass River that would permit pumping Lincoln Reservoir releases from the Embarrass River if suitable quantity and quality of water is maintained in that stream.

The City of Lawrenceville uses wells for water supply. Formerly, Embarrass River water was used but because of oil field wastes the quality of river water was badly degraded and the city changed its water supply source to a well field in the outwash sands and gravels of the Wabash River. The existing wells used by Lawrenceville have a maximum dependable draft of 4.0 mgd and it is believed the well field can be expanded to satisfy the anticipated need of 0.2 to 0.8 mgd additional water. Alternate sources of supply for Lawrenceville could be obtained from the Embarrass River if suitable quality of water were maintained or from the Wabash River.

VII. BENEFITS OF STORAGE

Evaluation Method

The time available for the Lincoln Reservoir study permitted only a preliminary appraisal of needs for water supply and water quality control. In this preliminary appraisal, a range of needs has been determined on the basis of the best estimates that could be made in the available time. Greater needs than those that have been anticipated may develop.

The needs for water supply and water quality control can be met as they develop on a piecemeal basis, but a more efficient method would be to determine all the needs and supply them with a single multi-purpose project. The benefits realized by this latter method would be equivalent to the savings or the decrease in costs from the more expensive alternates to the single project.

Alternate Plans

An alternate plan could be used to provide water for municipal and industrial water supply in place of the multi-purpose Lincoln Reservoir. This plan would require the individual communities to provide their own separate water supplies. Water for quality control purposes would be supplied most economically from a single reservoir upstream from Charleston.

This alternate to the proposed multi-purpose Lincoln Reservoir would require the construction of an additional impoundment for Charleston or the enlargement of the present impoundment when the present reservoir capacity is no longer sufficient. Similarly, Mattoon would have to plan for additional water but possibly not before the year 2000. Newton, which

VII. BENEFITS OF STORAGE

Evaluation Method

The time available for the Lincoln Reservoir study permitted only a preliminary appraisal of needs for water supply and water quality control. In this preliminary appraisal, a range of needs has been determined on the basis of the best estimates that could be made in the available time. Greater needs than those that have been anticipated may develop.

The needs for water supply and water quality control can be met as they develop on a piecemeal basis, but a more efficient method would be to determine all the needs and supply them with a single multi-purpose project. The benefits realized by this latter method would be equivalent to the savings or the decrease in costs from the more expensive alternates to the single project.

Alternate Plans

An alternate plan could be used to provide water for municipal and industrial water supply in place of the multi-purpose Lincoln Reservoir. This plan would require the individual communities to provide their own separate water supplies. Water for quality control purposes would be supplied most economically from a single reservoir upstream from Charleston.

This alternate to the proposed multi-purpose Lincoln Reservoir would require the construction of an additional impoundment for Charleston or the enlargement of the present impoundment when the present reservoir capacity is no longer sufficient. Similarly, Mattoon would have to plan for additional water but possibly not before the year 2000. Newton, which

satisfies its water needs from the Embarrass River, would need only a token amount of storage to insure a firm yield equal to its estimated future needs.

The communities of Toledo, Greenup, and Ste. Marie would require additional supplies but not necessarily from a surface water source. It is assumed from the anticipated increase in needs that these three communities could satisfy their needs from ground water sources.

Lawrenceville might have its additional needs supplied by a single purpose reservoir on some tributary upstream or it could obtain water from the Wabash River. Until the oil field wastes are controlled, it seems wiser to plan on expansion of the existing well field to its ultimate capacity as necessary.

Water Supply Benefits

The costs of the cheapest alternate sources of supply for the communities in need of additional water may be taken as a measure of the minimum value of the benefits gained from the Lincoln Reservoir project.

It is anticipated that the city of Mattoon will need about 1700 acre-feet of useable storage to provide about 1.5 mgd additional water by the year 2010. An alternate to acquiring this storage in the proposed Lincoln Reservoir would be the construction of a single purpose water supply reservoir on a tributary stream. Small tributaries to Kaskaskia, Little Wabash, or Embarrass River are near to Mattoon which is situated on a divide. Because ground water supplies have been insufficient for Mattoon's needs, two impoundments have been built. Any new impoundment

is likely to require about four miles of pipeline. Use of water from the proposed Lincoln Reservoir would require from 10 to 12 miles of pipeline, or from 6 to 8 miles of pipeline more than would a nearby reservoir.

The cost of constructing a single purpose reservoir having a capacity of 1700 acre-feet would be about $800,000. Thus, the minimum value of benefits from the provision of storage of water for Mattoon's use would be that figure less the differential in pipeline cost, or about $550,000 in terms of 1963 dollars. Adjusted for operation and maintenance costs, amortized for a period of 50 years beginning in 1970, and discounted to the year 2000 when Mattoon's additional water supply need for increased safe yield is expected to begin, the minimum annual value of benefits to Mattoon would be about $10,000 per year. This minimum value reduced to an annual value would be about $79,000 per year.

No estimate of possible benefits has been made for the communities of Toledo, Greenup, and Ste. Marie because it is believed that existing and expanded well fields will be adequate to supply the needs of these communities. In view of the generally cheaper cost of treating well water, it is believed storage costs of a surface water supply would exceed the benefits.

The city of Newton is expected to need a dependable river flow of about 2.0 mgd in addition to the normal river flow in the year 2010. During the lowest flow of the Embarrass River in the period of record available, a token usable storage volume of 20 acre-feet would have given the necessary dependable flow in the Embarrass River and no benefit has been assessed for this token storage.

The city of Lawrenceville is expected to continue use of its existing well field to the year 2010 without need for water from an additional source.

Adjusted Value of Storage

The minimum value of storage required for water supply from the proposed Lincoln Reservoir is at least equal to the cost of the two single purpose reservoirs that would be required for Mattoon and Charleston less the difference in cost of pipeline to service Mattoon. This total adjusted value is about $1,850,000, or about $89,000 per year.

The amount of the annual benefits of the municipal and industrial water from the proposed reservoir has been computed by converting the net savings in capital cost to an annual basis by amortizing for 25 years at 4 per cent and converting to an annual basis for a 50-year period at 3 per cent beginning in 1970. Annual operation and maintenance costs of the alternate were added to this figure and annual operation and maintenance of any necessary pipeline were deducted. The resulting benefit figure then was discounted to the year when the supply would become necessary.

It should be noted that the treated wastes of Mattoon and Charleston amounting to more than 100 per cent of water use from the proposed Lincoln Reservoir would be discharged into the proposed reservoir by way of Kickapoo Creek. The difference in water use and treated waste return is caused by the diversion of Mattoon's wastes from the Little Wabash River.

Water Quality Control Benefits

The critical point on the Embarrass River will be below Newton when the proposed Lincoln Reservoir is constructed. However, under existing

conditions, the water quality at and below the mouth of Kickapoo Creek is more critical. At this juncture, treatment plant effluent from Mattoon and Charleston enters Embarrass River.

After construction of the proposed Lincoln Reservoir, it is expected that these two cities will provide adequate treatment of their wastes.[9] Following this degree of treatment, no adverse affects would be expected in the main body of the proposed reservoir.

Downstream from the proposed reservoir, the city of Newton utilizes the Embarrass River as a source of supply. The flow believed to be reasonable for the users downstream from the Lincoln Reservoir is the minimum seven consecutive day average flow with a frequency of once in five years. This quantity has been selected because the periods of increased flow which presently are available to the downstream users will not occur with the same frequency and magnitude after construction of the proposed Lincoln Reservoir.

If this release rate from the reservoir is maintained, it is believed that adequately treated wastes from Greenup and Toledo can be assimilated without degrading the quality of the river at Newton below acceptable standards for water supply. Newton can then utilize the river for its supply and the remaining flow will be sufficient to receive and assimilate Newton's adequately treated wastes.

To maintain a flow of 21 cfs in the Embarrass River would require a draft on storage which could be provided by an impounding reservoir having a usable storage of 5400 acre-feet of water.

An alternate to the use of water from the proposed reservoir for quality control would be for the city of Newton to construct storage ponds for its wastes during periods when sufficient river flow is not available to assimilate the wastes. This alternate is not considered practical for the reason that possibly sixty days storage might be required and based upon projections, suitable sites for storage ponds of adequate size would not be available, and for a further reason that present State regulations would not compel Newton to use this method of control. Besides being impractical, this alternate would deprive downstream communities of river flow as an emergency source of water during fires. For the above reasons, this alternate is not recommended.

A second alternate would be for Newton to dispose of its wastes by distillation process. The process cost of this alternate would be prohibitive for Newton and is not required by the State. Therefore, this alternate is not satisfactory.

A third alternate for the community of Newton and other downstream communities, is the construction of a single-purpose reservoir from which stored water could be released to yield the desired flow. The storage draft that would be required would be 5400 acre-feet.

Downstream from Newton, the North Fork Embarrass River and other tributaries flow into the Embarrass River before that stream reaches Lawrenceville. On the basis of presently available information, it is believed that oil field wastes create a continually degraded condition in the Embarrass River from Lawrenceville to the mouth. Because of this degraded condition, it is not suggested that the Embarrass River be considered a

potential water supply source until this adverse condition is corrected. Further studies and investigations may indicate whether oil field wastes are receiving adequate treatment or whether other methods of controlling wastes are applied at the source.

When further studies are made, an analysis of oil field and refinery wastes can be made and the water quality of Embarrass River can be reconsidered in light of the data which then will be available.

At the present time, available information indicates that 21 cfs would be sufficient release from the proposed reservoir to maintain a suitable water quality in the river to the point downstream where brine wastes enter. Brine wastes control flows are not included in this estimate.

The minimum value of benefits to be derived from water quality control on the Embarrass River will be at least equal to the cost of a single purpose reservoir that would yield 21 cfs at the proposed Lincoln dam site. It is estimated that 5400 acre-feet of water storage would be required in such a reservoir. The cost of the single purpose structure would be about $1,600,000 as adjusted to 1963 construction costs by the index in Engineering News Record. This value would be about $80,000 annually.

In order to insure that water of satisfactory quality is released from the proposed Lincoln Reservoir, consideration should be given to multiple outlets. One should be in the upper levels, one at middle depth, and one in the lower levels. Otherwise, if water can only be released from levels near the bottom or below the thermocline, the quality of water may be poor owing to absence of dissolved oxygen and the presence of hydrogen sulphide as well as other undesirable traits.

VIII. BIBLIOGRAPHY

1. U. S. Department of the Interior, Geological Survey, Surface Water Records of Illinois, 1962. Champaign, Illinois.

2. U. S. Department of Health, Education, and Welfare, Public Health Service, Municipal Water Facilities Inventory as of January 1, 1958, Volume 5, Washington, U. S. Government Printing Office, 1960.

3. U. S. Department of the Interior, Geological Survey, Letter Report to the U. S. Army Corps of Engineers dated November 27, 1963.

4. The Embarrass Basin, Wabash Valley Interstate Commission.

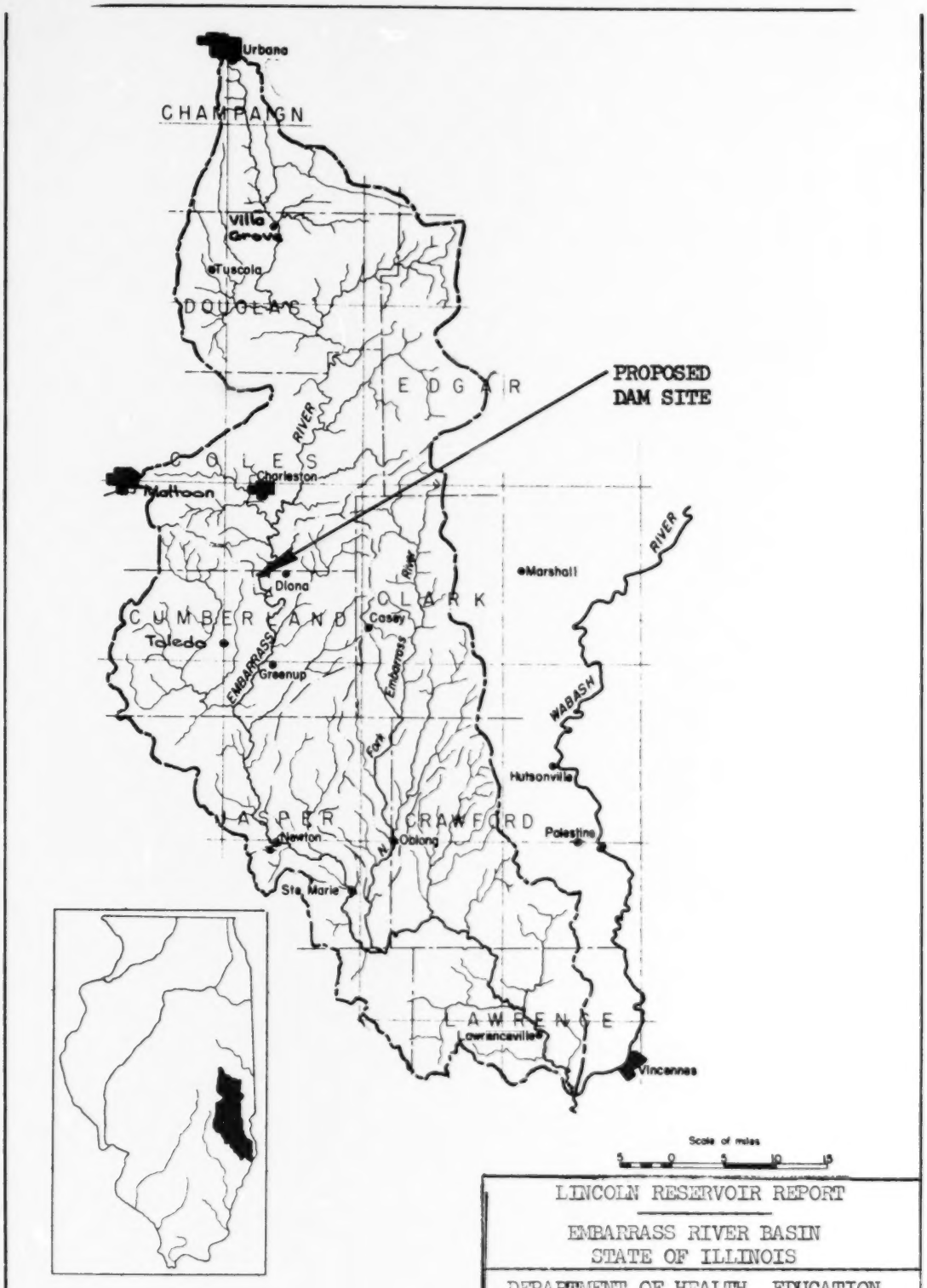
5. Illinois State Water Survey - Bulletin No. 40, State of Illinois, State Water Survey Division, Urbana.

6. Illinois Department of Public Health, Division of Sanitary Engineering, Laboratory Analysis of Illinois Streams Data, Unpublished data.

7. U. S. Department of Health, Education, and Welfare, Public Health Service, 1962 Inventory Municipal Waste Facilities, Volume V, Washington, D. C., U. S. Government Printing Office, 1963.

8. Illinois Department of Public Health, Division of Sanitary Engineering, State of Illinois, Sanitary Water Board, Technical Release 20-15.

9. Illinois Department of Public Health, Division of Sanitary Engineering, State of Illinois, Sanitary Water Board, Technical Release 20-11.



LINCOLN RESERVOIR REPORT

EMBARRASS RIVER BASIN
STATE OF ILLINOIS

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

OHIO RIVER BASIN PROJECT
EVANSVILLE, INDIANA FIELD STATION

Map furnished through courtesy of The U. S. Geological Survey.

FIGURE I